Cost Models for Bitstream Access Service

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INTRODUCTION

The European Regulatory Framework requires National Regulatory Authorities (NRAs) to conduct market analysis for a predefined set of markets that used to be subject to ex ante regulation (due to Significant Market Power (SMP) of the incumbent network operator), or that are expected to be associated with SMP. The service under consideration in this article—Bitstream Access—is considered in Market 12 (see ERG, 2003).

Depending on the results of the market analysis, NRAs can impose remedies on the SMP operator, like cost accounting, long run incremental cost (LRIC), based ex ante regulation, or other requirements. Many European NRAs foresee price control of bitstream access service (BAS).

This contribution provides a cost model for BAS, which takes into account the required bandwidth of a service and QoS parameters, mainly the average delay over the corresponding bitstream access configuration. The contribution shows in the second section the basic ideas of the FL-LRIC model and especially the so-called Total Element Long Run Increment Cost model (TELRIC) and the basic aspects of BAS network architecture. The third section deduces the proper TELRIC model for BAS under QoS differentiation, mainly considering delay limits. The section introduces two applications, one based on assuring QoS under the overengineering concept, and the other on traffic separation over different queues.

LRIC COST MODELS FOR BITSTREAM ACCESS SERVICES

LRIC constitutes the dominant costing standard, in case of SMP and ex ante price control, recommended by the European Regulatory Framework (see BNA, 2005; Hackbarth, 2007). There are basically two methodologies to design LRIC cost models: TSLRIC (Total Service LRIC), and TELRIC (Total Element LRIC) (see Courcubetis & Weber, 2003). TSLRIC model is oriented to services and is used as basis for setting fixed network charges, but it doesn't include common costs of joint production, as they are not incremental in providing a service.

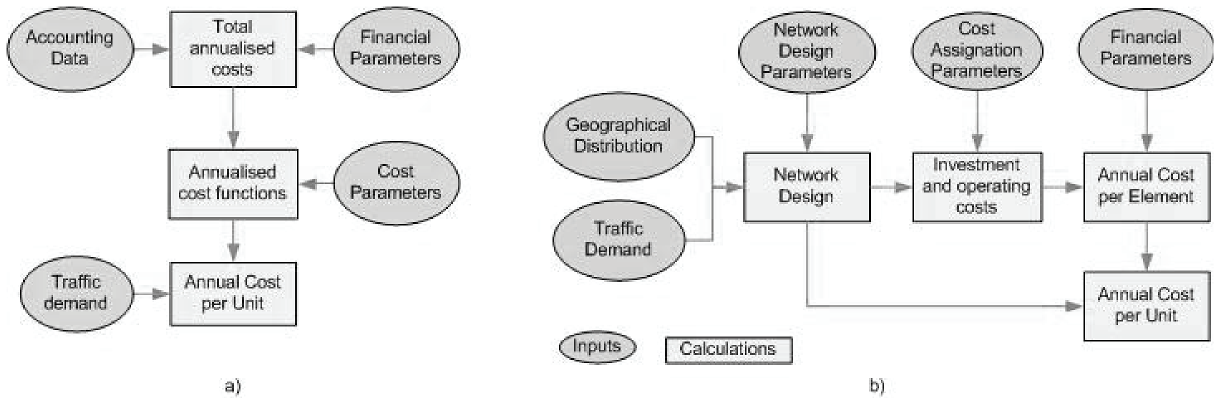
TELRIC model is oriented to network elements. As the elements are dimensioned according to all services using it, TELRIC provides that the cost of a network element used by different services is shared by the services in relation to the intensity of use that each one does of the element. TELRIC can be designed from two different perspectives, Top-Down (Figure 1a) and Bottom-Up (Figure 1b).

Under Top-Down modeling, historical accounting data are taken as a starting point. It relies on the actual network architectures and configurations of a specific carrier, and (implicitly) accounts for its efficiency.

Bottom-Up approach models the network of a hypothetical operator. This efficient operator employs the best current technology, and is not constrained by decisions of the past. Therefore, it reflects an efficient cost structure relevant to the market and regulatory decisions. Hence, for regulation purposes, TELRIC model with bottom-up approach is mainly used (BNA, 2005; Brinkmann, Hackbarth, Ilic, Neu, Neumann, & Portilla, 2007; Hackbarth, Portilla, & Diaz, 2005).

The TELRIC Bottom-Up cost models require knowledge on the traffic on all network elements. Since the traffic information is required for network dimensioning, it must reflect the demand in the high load period (HLP). Furthermore, this information on annual demand is necessary for costing.

Figure 1. (a) Top-down approach;(b) bottom-up approach



The reference architecture network for an end-to-end BAS tunnel is structured into four network segments, as shown in Figure 2 (Cave, 2003; Yager, 1999) where the DSLAM provides the first traffic aggregation point. The traffic from the user is routed over the different network sections, up to the interconnection point with the Internet service provider. The BAS reference architecture is currently implemented over an ATM access and an IP core network structure. Access network over Ethernet technology and IP core transport is emerging, but its implementation has still-low penetration. Anyway, the TERLIC model deduced in this contribution is based on generic queuing models, and hence, valid for any type of network elements.

TELRIC COST MODEL FOR BAS UNDER QOS DIFFERENTIATION

As shown in Figure 2, a BAS connection is routed over a chain of network elements. We consider as a main QoS parameter, the average value of the total delay over the BAS tunnel. We model each network element by a queuing system and consider that total delay is approximated by the sum of the individual delays over the network elements. To fulfill this delay, a corresponding mechanism must be applied. We consider three methods (McDysan, 2000):

1. Traffic aggregation and routing over common capacities without any additional traffic engineering mechanism.
2. Traffic aggregation and routing over common capacities with a priority waiting scheme.
3. Traffic segregation and routing over separated tunnels.

The first and second methods have the advantage that the traffic integration on common capacities leads to a reduction of the queuing delay against a traffic routing over separated tunnels. The trade off resulting from traffic routing on common capacities is that it causes correlation between the delays of the different traffics, which difficult the QoS differentiation.

The first method uses overengineering to ensure the QoS of the most restrictive service over the current best effort Internet. Acceptable QoS values for real time and streaming services are implemented by a reduced use of the network capacities; typically between 70 and 75%. The effort for traffic engineering is strongly reduced, but some unpredicted overload might lead to an unacceptable degradation of the QoS.

The second method corresponds to priority traffic routing implemented by the DiffServ scheme in Internet (Blake, Black, Carlson, Davies, Wang, & Weiss, 1998). It assures, under a non-pre-empty priority waiting scheme, that the traffic with higher priority is nearly not influenced by the lower priority traffic, and hence, provides relatively better QoS values. The limit results from the fact that priority routing does not provide a fixed QoS guaranty (e.g., an overload from higher priority traffic provides a reduction of the QoS for traffic with lower priority). Anyway, this effect can be reduced by applying additional methods of traffic management as weighted fair queuing mechanism, or reduced queuing length for high priority traffic (Cisco, 2001). Hence, it's required higher effort for traffic engineering than in the case of over-engineering.